US009459491B2

(12) **United States Patent**
Yi

(10) **Patent No.: US 9,459,491 B2**
(45) **Date of Patent: Oct. 4, 2016**

(54) **MIRROR DISPLAY DEVICE AND MANUFACTURING METHOD THEREOF**

(71) Applicant: **Samsung Display Co., Ltd.**, Yongin-si, Gyeonggi-do (KR)

(72) Inventor: **Jung Hwan Yi**, Yongin-si (KR)

(73) Assignee: **Samsung Display Co., Ltd.** (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 143 days.

(21) Appl. No.: **14/457,775**

(22) Filed: **Aug. 12, 2014**

(65) **Prior Publication Data**

US 2015/0227001 A1 Aug. 13, 2015

(30) **Foreign Application Priority Data**

Feb. 10, 2014 (KR) 10-2014-0014924

(51) **Int. Cl.**

G02F 1/13	(2006.01)
G02F 1/1335	(2006.01)
G02F 1/1333	(2006.01)
G02F 1/1347	(2006.01)

(52) **U.S. Cl.**

CPC ***G02F 1/133536*** (2013.01); ***G02F 1/13471*** (2013.01); ***G02F 1/133377*** (2013.01); ***G02F 1/133553*** (2013.01)

(58) **Field of Classification Search**

CPC G02F 1/133536; G02F 1/133377; G02F 1/133528; G02F 1/133526

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,495,719 B2	2/2009	Adachi et al.		
7,728,927 B2	6/2010	Nieuwkerk et al.		
2001/0022997 A1*	9/2001	Honda	G02B 5/3016	428/1.31
2004/0189907 A1*	9/2004	Tominaga	G02F 1/133528	349/115
2011/0273659 A1	11/2011	Sobecki		
2015/0042896 A1*	2/2015	Lee	G02F 1/1347	348/790
2015/0177563 A1*	6/2015	Cho	G02F 1/133536	349/96
2015/0219911 A1*	8/2015	Cho	H04N 13/0404	349/15

FOREIGN PATENT DOCUMENTS

JP	2005-321717	11/2005
KR	1020120026880 A	3/2012
KR	1020120074499 A	7/2012
KR	1020130104862 A	9/2013
KR	1020130107379 A	10/2013
KR	1020130107952 A	10/2013

* cited by examiner

Primary Examiner — Mariceli Santiago

(74) *Attorney, Agent, or Firm* — Innovation Counsel LLP

(57) **ABSTRACT**

A display device includes a display panel and a polarization conversion panel facing the display panel. The polarization conversion panel includes: an insulation substrate; an absorptive polarizer positioned on the insulation substrate; a first electrode positioned on the absorptive polarizer; a passivation layer formed on the first electrode while being spaced apart therefrom a microcavity interposed between the passivation layer and the first electrode, the passivation layer an injection hole; an overcoat formed on the passivation layer to cover the injection hole and seal the microcavity; a second electrode positioned on the overcoat; a reflective polarizer positioned on the second electrode; and a liquid crystal layer positioned in the microcavity.

8 Claims, 14 Drawing Sheets

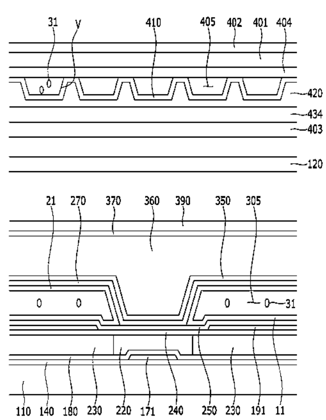

FIG. 1

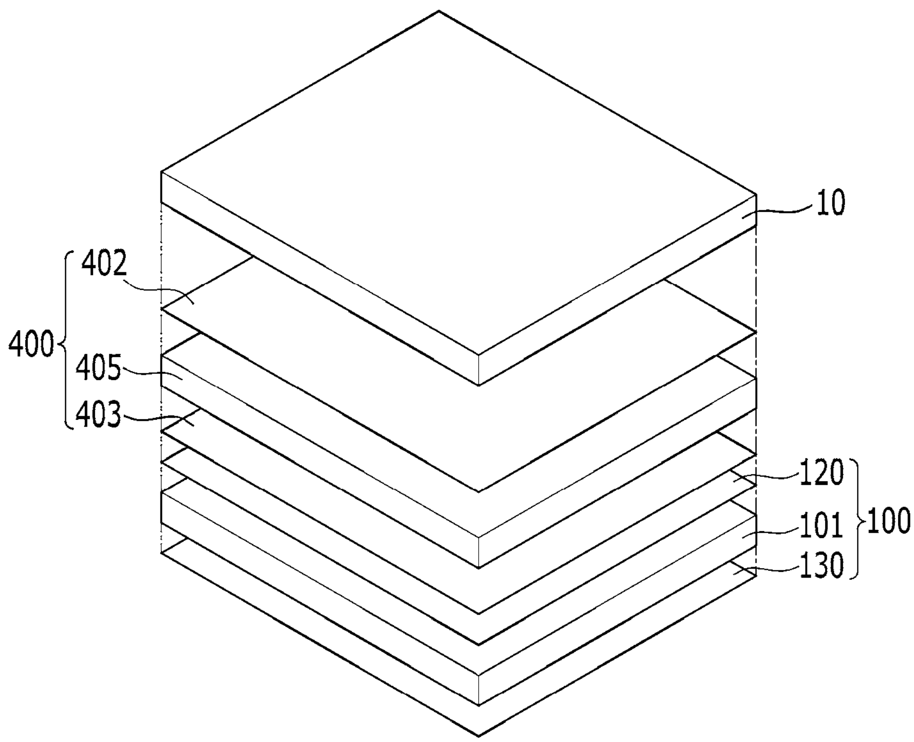

FIG. 2A

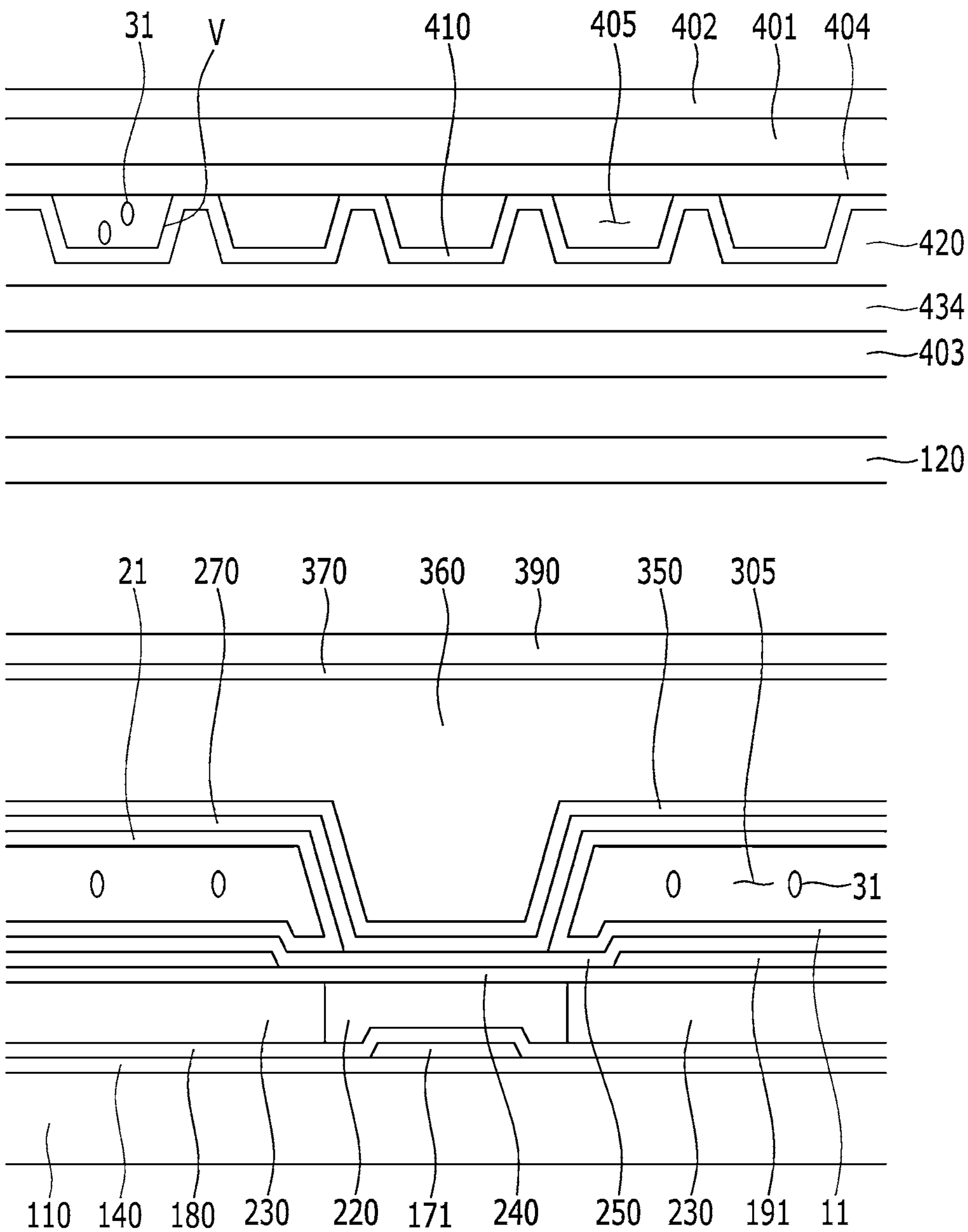
31
V
410
405
402
401
404
420
434
403
120
21
270
370
360
390
350
305
31
110
140
180
230
220
171
240
250
230
191
11

FIG. 2B

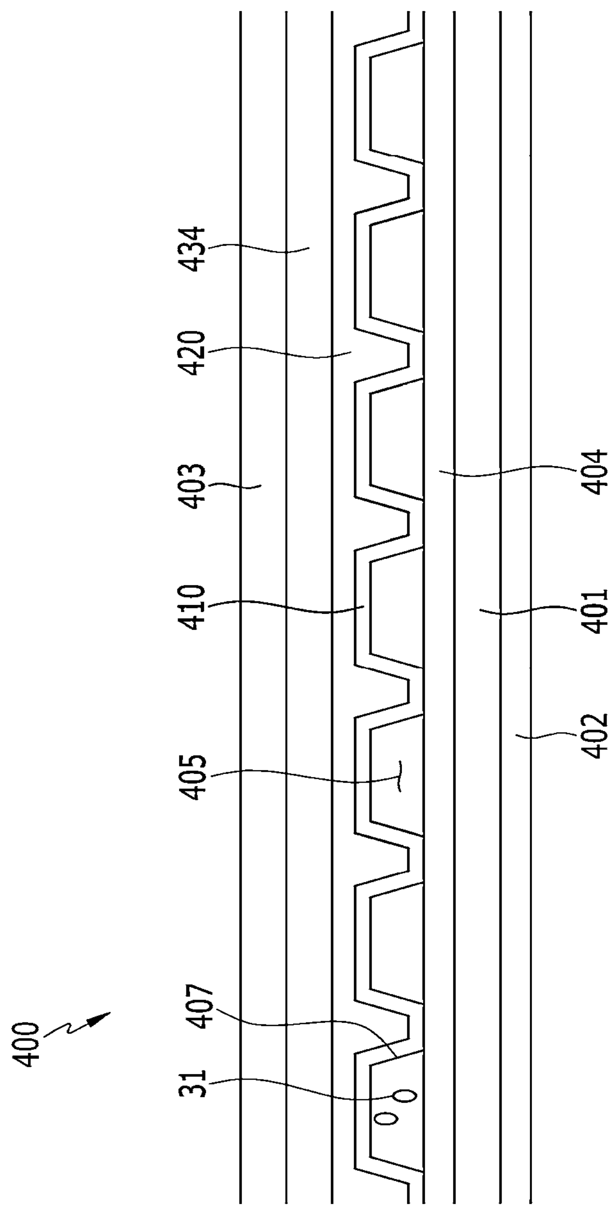

FIG. 3

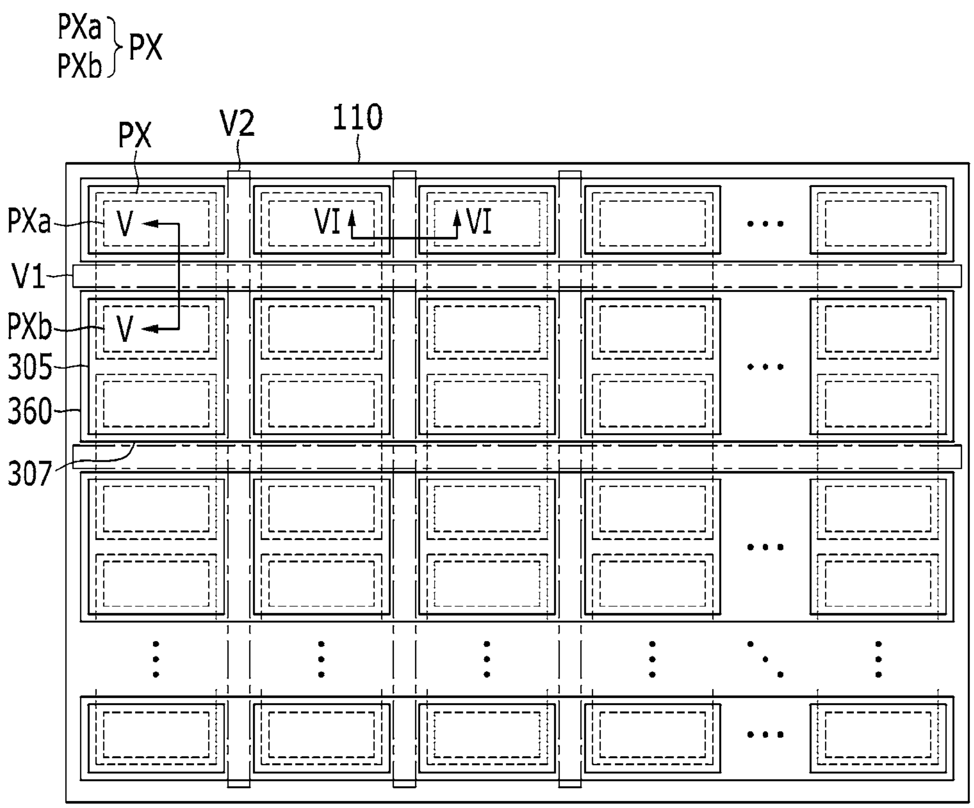

FIG. 4

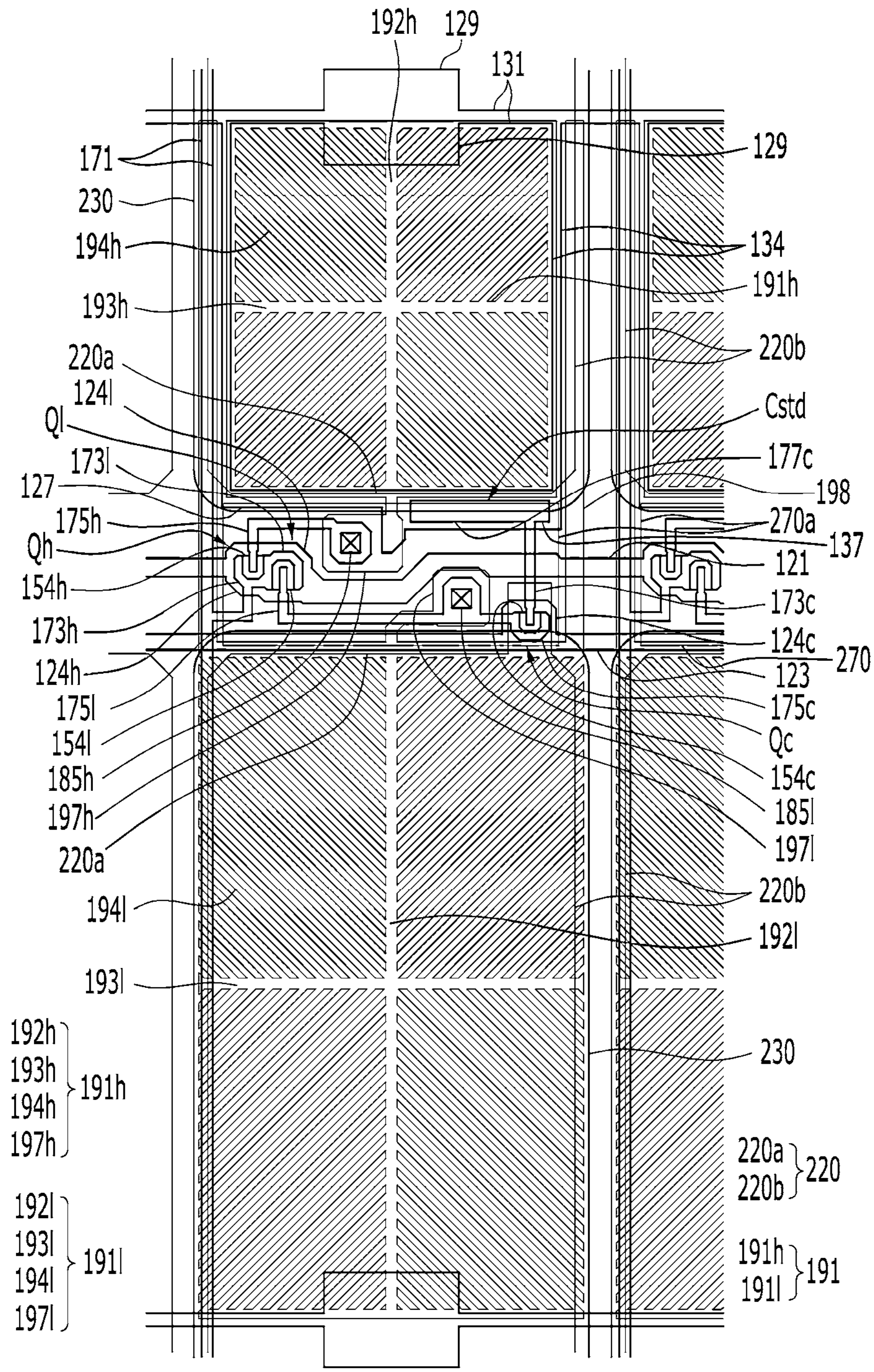
192h
129
131
129
171
230
194h
134
193h
191h
220b
220a
124l
Ql
Cstd
173l
177c
127
198
175h
270a
Qh
137
154h
121
173h
173c
124c
270
124h
123
175l
175c
154l
Qc
185h
154c
197h
185l
220a
197l
194l
220b
192l
193l
230
192h
193h
194h
197h
191h
220a
220b
220
192l
193l
194l
197l
191l
191h
191l
191

FIG. 5

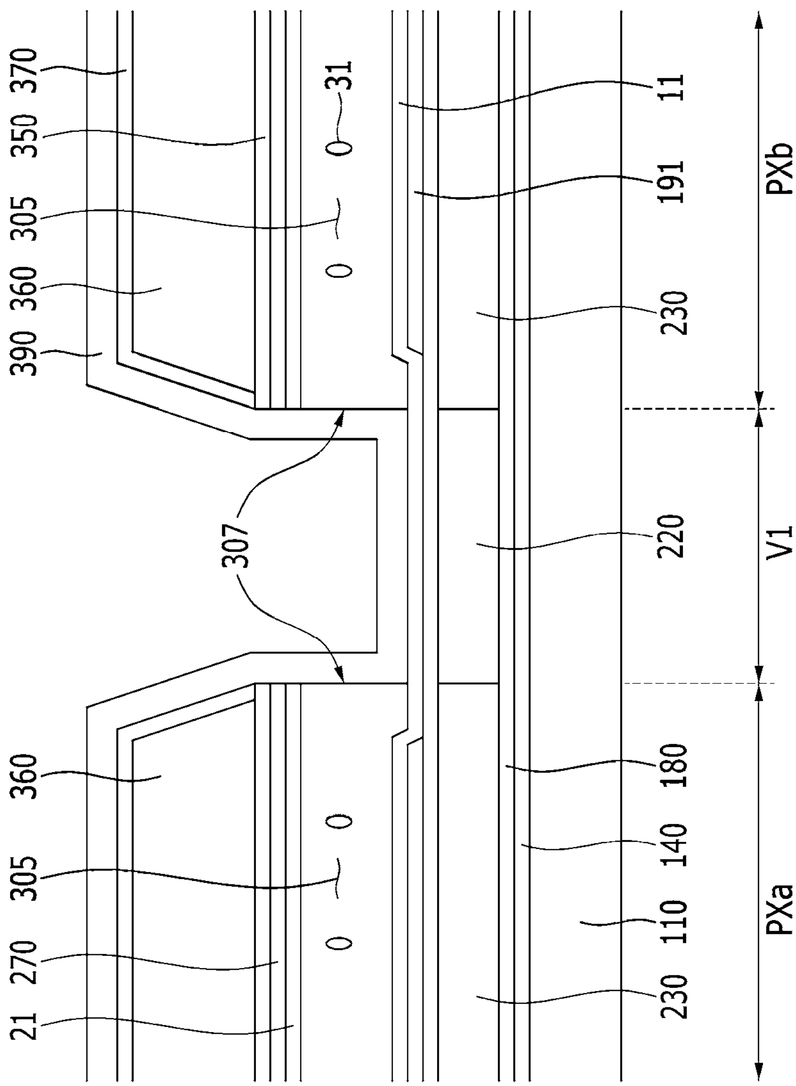
370
350
305
360
390
31
11
191
230
307
220
360
305
270
21
180
140
110
230
PXb
V1
PXa

FIG. 6

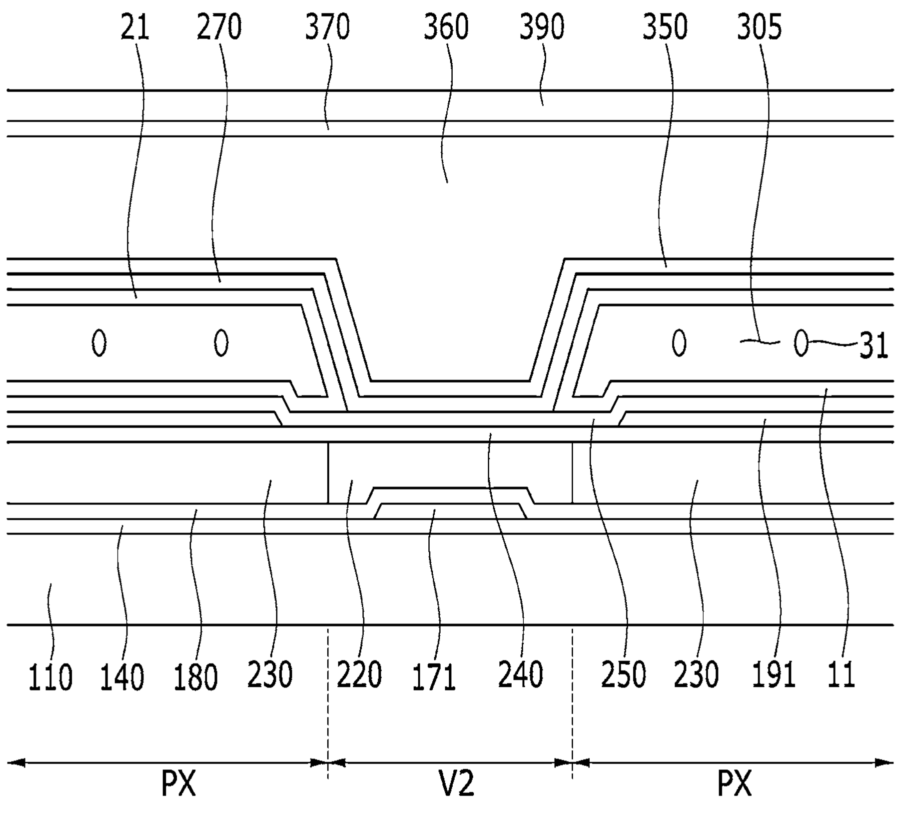
21
270
370
360
390
350
305
31
110
140
180
230
220
171
240
250
230
191
11
PX
V2
PX

FIG. 7

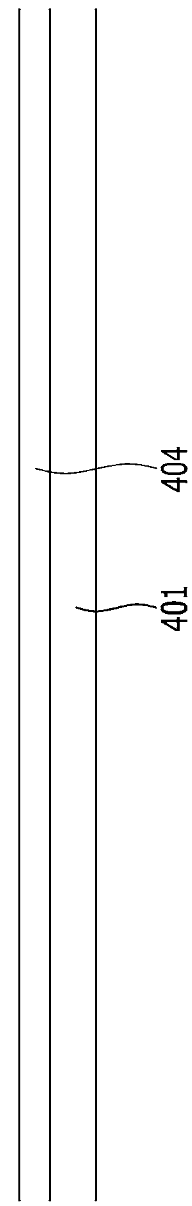

FIG. 8

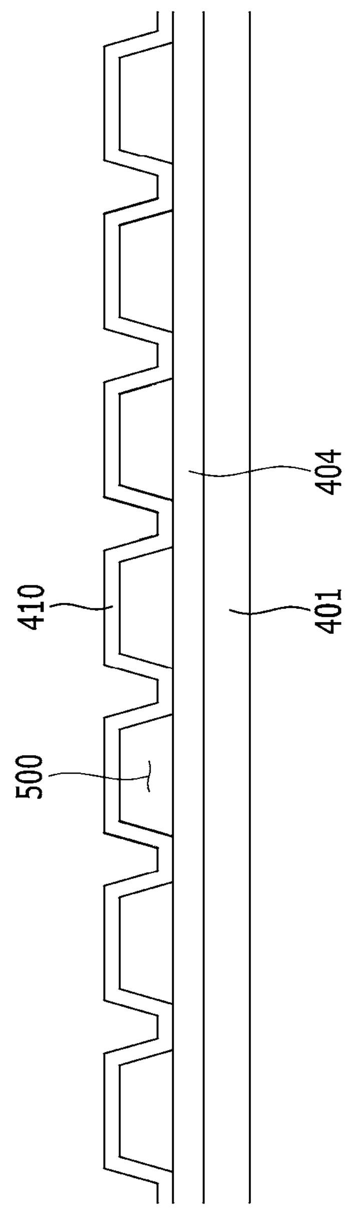

FIG. 9

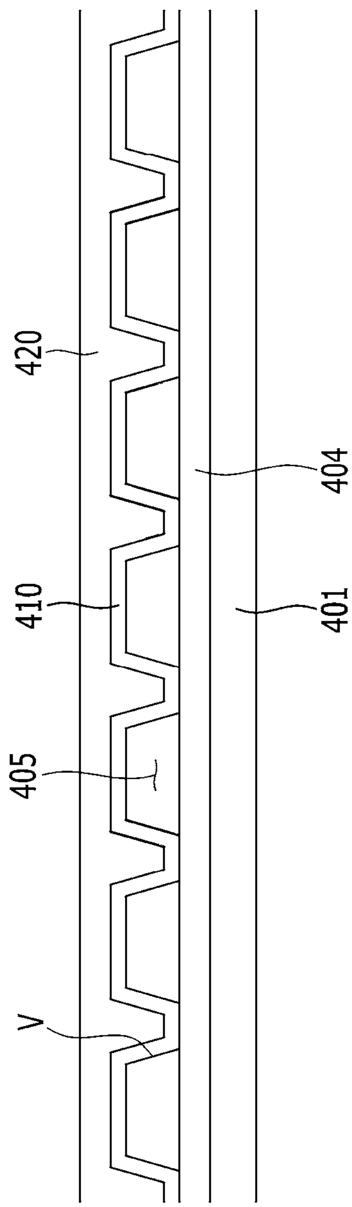

FIG. 10

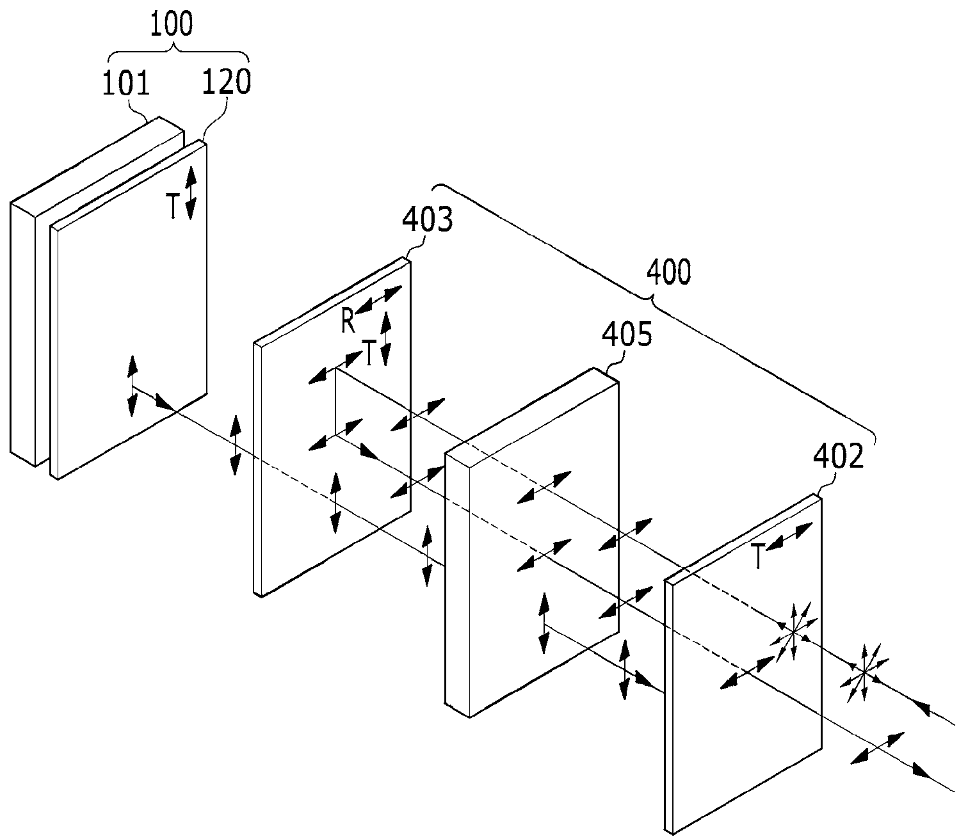

FIG. 11

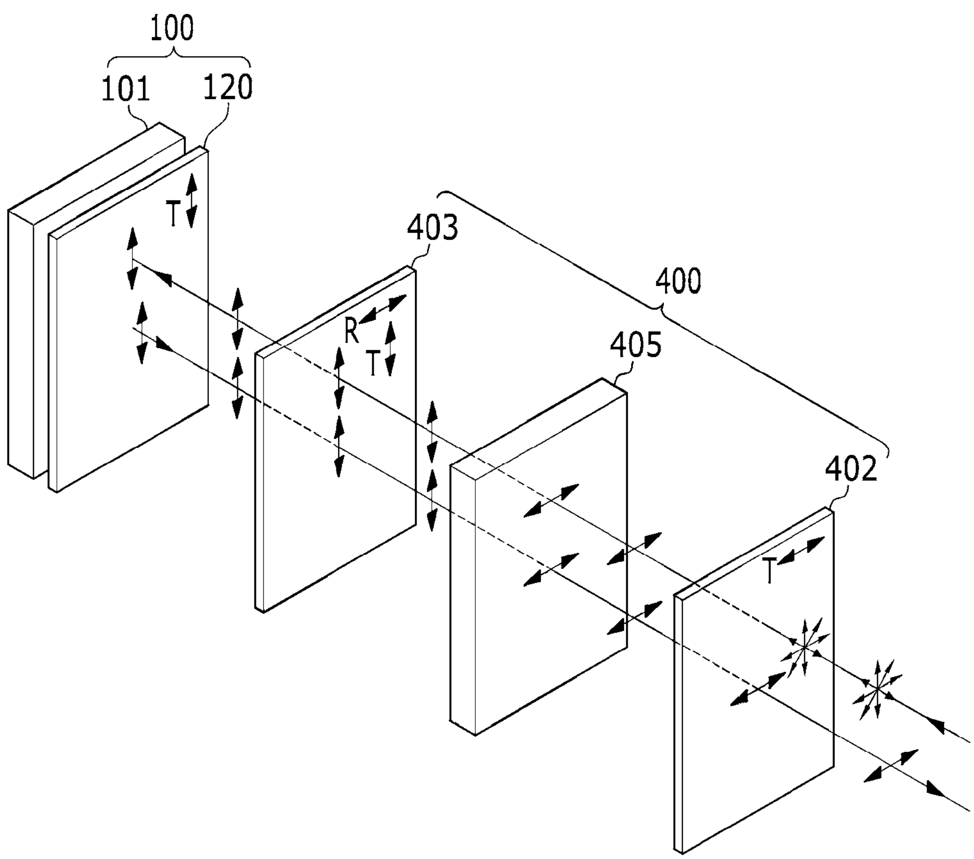

FIG. 12

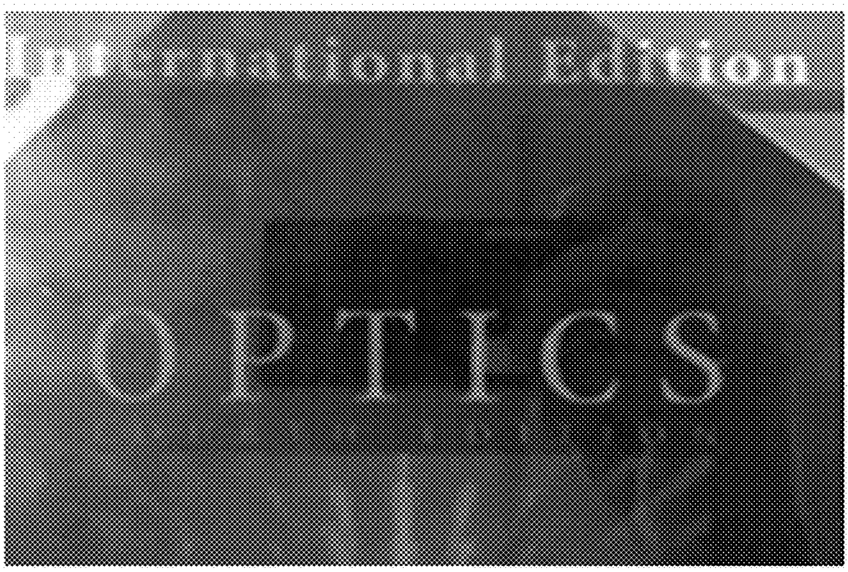

FIG. 13

MIRROR DISPLAY DEVICE AND MANUFACTURING METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2014-0014924 filed in the Korean Intellectual Property Office on Feb. 10, 2014, the entire contents of which are incorporated herein by reference.

BACKGROUND

(a) Field

The present invention relates to a mirror display device and a manufacturing method thereof.

(b) Description of the Related Art

A liquid crystal display is currently one of the most widely used flat panel displays, and includes two display panels on which electric field generating electrodes such as a pixel electrode and a common electrode are formed, and a liquid crystal layer interposed between the two display panels. The liquid crystal display displays an image by generating an electric field on a liquid crystal layer by applying a voltage to the field generating electrodes, determining alignment directions of liquid crystal molecules of the liquid crystal layer through the generated field, and controlling polarization of incident light.

The two display panels forming the liquid crystal display may include a thin film transistor array panel and an opposing display panel.

In the thin film transistor array panel, a gate line for transmitting a gate signal and a data line for transmitting a data signal are formed to cross each other, and a thin film transistor connected to the gate and the data lines, a pixel electrode connected to the thin film transistor, etc. may be formed.

The opposing display panel may be formed with a light blocking member, a color filter, a common electrode, etc.

Alternatively, the light blocking member, the color filter, and the common electrode may be formed on the thin film transistor array panel.

However, in a liquid crystal display in the related art, two sheets of substrates are inevitably used, and respective constituent elements are formed on the two sheets of substrates, and as a result, the display device becomes heavy and thick, incurs a high cost, and requires a longer processing time.

Meanwhile, personal hand-held terminals or liquid crystal displays for outdoor display purposes basically have a portable size to meet a user's need, and liquid crystal displays including an additional mirror function have recently been provided.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the disclosure and therefore it may contain information that does not form the prior art that is already known to a person of ordinary skill in the art.

SUMMARY

A display device and a manufacturing method thereof that are capable of reducing weight, thickness, cost, and processing time by using a single substrate when manufacturing the display panel are provided.

In addition, a display device that is capable of implementing a mirror mode in addition to a display mode is provided.

A display device includes a display panel and a polarization conversion panel facing the display panel. The polarization conversion panel includes: an insulation substrate; an absorptive polarizer positioned on the insulation substrate; a first electrode positioned on the absorptive polarizer; a passivation layer formed on the first electrode while being spaced apart therefrom and a microcavity interposed between the passivation layer and the first electrode, the passivation layer an injection hole; an overcoat formed on the passivation layer to cover the injection hole and seal the microcavity; a second electrode positioned on the overcoat; a reflective polarizer positioned on the second electrode; and a liquid crystal layer positioned in the microcavity.

The display panel may contact the reflective polarizer.

The first and second electrodes may be made of a transparent conductive oxide (TCO).

A first polarizer positioned between the display panel and the reflective polarizer may be further included, and transmissive axes of the first polarizer and the reflective polarizer may coincide with each other.

The transmissive axis of the reflective polarizer may be perpendicular to a transmissive axis of the absorptive polarizer.

A reflective axis of the reflective polarizer may be parallel to the transmissive axis of the absorptive polarizer.

The transmissive and reflective axes of the reflective polarizer may be perpendicular to each other.

The display panel may include: a substrate including a plurality of pixel areas that are arranged in a matrix form including a plurality of pixel rows and pixel columns; a thin film transistor formed on the substrate; a pixel electrode formed in the pixel area while being connected to the thin film transistor; a roof layer formed on the pixel electrode while being spaced apart therefrom and interposing a display microcavity therebetween; a liquid crystal layer filling the display microcavity; and an overcoat formed on the roof layer to cover the first injection hole and seal the display microcavity.

A manufacturing method of a display device includes: preparing a display panel; forming a first electrode on a surface of a separate insulation substrate; forming a sacrificial layer on the first electrode; forming a passivation layer on the sacrificial layer; forming an injection hole by etching the passivation layer such that the sacrificial layer is partially exposed; forming a microcavity between the passivation layer and the first electrode by removing the sacrificial layer; forming a liquid crystal layer by injecting a liquid crystal material through the injection hole; sealing the microcavity by forming an overcoat on the passivation layer; forming a second electrode on the overcoat; positioning a reflective polarizer on the second electrode; and positioning an absorptive polarizer on the other side of the insulation substrate.

The preparing of the display panel may include: forming a thin film transistor on a substrate including a plurality of pixel areas that are arranged in a matrix form including a plurality of pixel rows and pixel columns; forming a pixel electrode that is connected to the thin film transistor in the pixel area; forming a sacrificial layer, which is connected along the pixel column, on the pixel electrode; forming a roof layer on the sacrificial layer; forming a first injection hole by patterning the roof layer such that the sacrificial layer is partially exposed; forming a display microcavity between the pixel electrode and the roof layer by removing the sacrificial layer; forming a liquid crystal layer by injecting a liquid crystal material through the first injection hole; and sealing the display microcavity by forming an overcoat on the roof layer.

The method may further include combining the display panel and the reflective polarizers such that they contact each other.

The first and second electrodes may be made of a transparent conductive oxide (TCO).

The method may further include forming a first polarizer between the display panel and the reflective polarizer, wherein transmissive axes of the first polarizer and the reflective polarizer may coincide with each other.

The transmissive axis of the reflective polarizer may be perpendicular to a transmissive axis of the absorptive polarizer.

A reflective axis of the reflective polarizer may be parallel to the transmissive axis of the absorptive polarizer.

The transmissive and reflective axes of the reflective polarizer may be perpendicular to each other.

According to the display device and the manufacturing method thereof, the weight, thickness, cost, and processing time can be reduced by using the single substrate in manufacturing the display panel.

In addition, through the display device implementing a mirror mode and the manufacturing method thereof, convenience may be provided for the user.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a display device according to an example embodiment.

FIG. **2**A is a partial cross-sectional view of the display device according to the example embodiment.

FIG. **2**B is a cross-sectional view of a polarization conversion panel according to the example embodiment.

FIG. **3** is a top plan view of a display panel according to the example embodiment.

FIG. **4** is a top plan view of one pixel of the display panel according to the example embodiment.

FIG. **5** is a partial cross-sectional view of the display panel according to the example embodiment taken along the line V-V of FIG. **3**.

FIG. **6** is a partial cross-sectional view of the display panel according to the example embodiment taken along the line VI-VI of FIG. **3**.

FIGS. **7** to **9** are cross-sectional views of a polarization conversion panel according to a manufacturing method thereof.

FIGS. **10** and **11** are schematic views showing how a mirror mode is implemented according to the example embodiment of the present invention.

FIGS. **12** and **13** are images of the display device according to the example embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present disclosure will be described more fully hereinafter with reference to the accompanying drawings, in which example embodiments are shown.

As those skilled in the art would realize, the described embodiments may be modified in various different ways, all without departing from the spirit or scope of the present invention.

In the drawings, the thickness of layers, films, panels, regions, etc. are exaggerated for clarity.

Like reference numerals designate like elements throughout the specification.

It will be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element, or intervening elements may also be present.

In contrast, when an element is referred to as being "directly on" another element, there are no intervening elements present.

A display device according to an example embodiment will now be described with reference to FIGS. **1** and **2**.

FIG. **1** is an exploded perspective view schematically showing a display device according to an example embodiment, FIG. **2**A is a partial cross-sectional view of the display device according to the example embodiment, and FIG. **2**B is a cross-sectional view of a polarization conversion panel according to the example embodiment.

Referring to FIG. **1**, the display device according to the example embodiment includes a display panel **100**, a polarization conversion panel **400**, and a window **10**.

The window **10** is positioned in front of the display panel **100** to protect it.

The window **10** protects the display panel from being broken by external impact.

The window **10** may be attached to the display panel **100** or the polarization conversion panel **400** by a predetermined adhesive layer (not shown).

Alternatively, the display panel **100** or the polarization conversion panel **400** may be formed so as to be spaced apart from the window **10** with an air layer interposed therebetween.

The display panel **100** may include a liquid crystal array panel **101** and polarizers **120**, **130** positioned at opposite sides of the liquid crystal array panel **101**.

In the present disclosure, a liquid crystal display panel in which the liquid crystal array panel **101** generates a vertical electric field is described, but it is not limited thereto. Alternatively, the display panel may be a display device such as a plasma display panel (PDP), an organic light emitting diode (OLED) display device, a surface conduction electron-emitter display (SED), a field emission display (FED), a vacuum fluorescent display (VFD), an e-paper, etc.

A first polarizer **120** and a second polarizer **130** may be positioned on opposite sides of the liquid crystal array panel **101** so as to polarize light incident from a light unit (not shown).

Particularly, a transmissive axis of the first polarizer **120** positioned between the polarization conversion panel **400** and the liquid crystal array panel **101** coincides with a transmissive axis of a reflective polarizer **403** that the polarization conversion panel **400** includes.

In order for the image displayed on the liquid crystal array panel **101** to be transmitted to a user through the reflective polarizer **403**, the transmissive axes of the reflective polarizer **403** and the first polarizer **120** should be parallel to each other.

In addition, when the liquid crystal array panel **101** is used as the display panel according to an example embodiment, the display device may further include the light unit (not shown) in addition to the first and second polarizers **120** and **130**.

The light unit includes a light source that emits light, and a light guide plate (not shown) for guiding the received light toward the display panel **100** and the polarization conversion panel **400**.

As an example of the present invention, the light source may include at least one light emitting diode (LED), which may be disposed on at least one lateral side of the light guide plate.

That is, the light source may be an edge-type light unit positioned at the lateral sides of the light guide.

However, the light unit is not limited thereto, and it may have a direct-type structure in which the light source is positioned directly under a diffusion plate (not shown), and the light source may consist of a fluorescent lamp instead of the light emitting diode (LED).

In the present disclosure, the liquid crystal display panel has been used as the display panel, but it is not limited thereto, and an organic light emitting diode display panel may be used, and in this case, the second polarizer **130** and the light unit (not shown) may be omitted.

The polarization conversion panel **400** will now be described in more detail with reference to FIGS. **2**A and **2**B.

The display panel illustrated in FIG. **2**A together with the polarization conversion panel **400** will be described below in more detail.

FIG. **2**A illustrates that the polarization conversion panel and the display panel are spaced apart from each other, but they can be combined by an adhesion member and the like.

Referring to FIG. **2**B, the polarization conversion panel **400** reflects or transmits light depending on whether or not a voltage is applied thereto, and according to the example embodiment, the polarization conversion panel **400** is positioned between the window **10** and the display panel **100**.

The polarization conversion panel **400** includes the reflective polarizer **403** positioned on the first polarizer **120** of the display panel **100**, a second electrode **434** positioned on the reflective polarizer **403**, a first electrode **404** that faces and is spaced apart from the second electrode **434**, and an absorptive polarizer **402**. A microcavity **405** injected with a liquid crystal layer containing liquid crystal molecules **31** and a plurality of passivation layers **410** may be positioned in a space between the second and first electrodes **434** and **404**.

Alternatively, according to the present example embodiment, the absorptive polarizer **402** may be positioned on an insulation substrate **401**.

This is for the polarization conversion panel **400** and the display panel to be separately manufactured and then combined.

The absorptive polarizer **402** is positioned on one surface of the insulation substrate **401**.

The absorptive polarizer **402** has a predetermined transmissive axis, and the transmissive axis of the absorptive polarizer **402** may be perpendicular to or parallel to the transmissive axis of the reflective polarizer **403** depending on liquid crystal modes.

Accordingly, only light vibrating in a direction parallel to the transmissive axis of the absorptive polarizer **402** may pass through the absorptive polarizer **402**, and the remainder of the light is absorbed by the absorptive polarizer **402**.

The first electrode **404** is positioned on the other surface of the insulation substrate **401**.

The first electrode **404** may be made of a transparent conductive oxide (TCO), and may have the same planar shape as the insulation substrate **401**, but it is not limited thereto.

The second electrode **434** is formed on the first electrode **404** such that it is spaced apart therefrom.

Similar to the first electrode **404**, the second electrode **434** may be made of a transparent conductive oxide (TCO), and may have a shape corresponding to the planar shape of the insulation substrate **401**.

However, the second electrode is not limited to the material or shape described above.

A plurality of microcavities **405** as well as the passivation layer **410** and an overcoat **420** that are used to form the microcavities **405** are formed between the first and second electrodes **404** and **434**.

That is, the microcavities **405** are enclosed by the first electrode **404**, the second electrode **434**, and the passivation layer **410**.

A width and an area of the microcavity **405** may be variously changed depending on a size and resolution of the display device.

In other words, according to an example embodiment, the microcavity **405** may be formed of a plurality of passivation layers and/or overcoats.

In the present disclosure, as shown in FIG. **2**A and FIG. **2**B, the microcavity **405** that is formed by the passivation layer and the overcoat will be described.

The microcavities **405** are positioned on the insulation substrate **401** of the polarization conversion panel **400**, and in particular, may be arranged in a matrix form.

In this case, a valley V that defines an independent microcavity may be positioned along the matrix direction.

The valleys V may be positioned along horizontal and vertical directions so as to define the microcavities **405** that are arranged in the matrix form.

The passivation layer **410** may be formed to cover all of the microcavities **405** and the first electrode **404**.

In this case, an injection hole **407** is formed such that the passivation layer **410** is partially removed to expose constituent elements positioned under the passivation layer **410**.

As an example, the passivation layer **410** may have a shape that extends in a column direction with respect to the insulation substrate **401**, and may be removed from the valleys to correspond to the valleys that are formed in a row direction.

Though not separately illustrated in FIGS. **2**A and **2**B, a first valley **V1** may be positioned to support the microcavity **405** while a second valley **V2** may be removed to form the injection hole **407** through which liquid crystals are injected inside the microcavity **405**. Each passivation layer **410** is formed to be separated from the substrate **401** between the valleys V of the microcavities **405** so as to form the microcavities **405**.

Further, in the valleys V between the microcavities **405** adjacent in a column direction, each passivation layer **410** is formed to be attached to the substrate **401** or the first electrode **404** such that it covers both lateral sides of the microcavities **405**.

As an example, the injection hole **407** may be formed to correspond to a region in which the valley V is positioned, but is not limited thereto, and it may be formed on a top surface of the microcavity.

A structure of the polarization inversion panel is described as an example, and it may be modified in various ways.

For example, an arrangement of the valleys V may be varied, and the passivation layer **410** may be formed such that it is separated from the substrate **401** between the valleys of the adjacent microcavities **405** and is attached to the substrate **401** or the first electrode **404** so as to cover both lateral sides of the microcavity **405**.

The liquid crystal layer including the liquid crystal molecules **31** that are injected through the injection hole **407** is positioned in the microcavity **405**.

The liquid crystal molecules **31** can be realigned by applying an electric field between the second and first electrode **434** and **404**.

As a result, rotation and phase delay of incident light toward the polarization conversion panel **400** can be adjusted by controlling the electric field between the second and first electrodes **434** and **404** from 0 V to a predetermined voltage.

The overcoat **420** may be formed on the passivation layer **410**.

The overcoat **420** is formed to cover the injection hole **407** through which the microcavity **405** is partially exposed.

That is, the overcoat **420** may seal the microcavity **405** such that the liquid crystal molecules **31** therein are not discharged to the outside.

Because the overcoat **420** contacts the liquid crystal molecules **31**, the overcoat **420** may be preferably made of a material that is not reactive with the liquid crystal molecules **31**.

For example, the overcoat **420** may be made of parylene and the like.

In the present disclosure, the overcoat **420** having a single layer has been illustrated, but it is not limited thereto, and it may consist of multiple layers such as a double layer or a triple layer structure.

The double layer structure consists of two layers that are respectively made of different materials.

The triple layer structure consists of three layers, and forming materials of adjacent layers are different from each other.

For example, the overcoat **420** may include a layer made of an organic insulating material and a layer made of an inorganic insulating material.

The second electrode **434** described above is positioned on the overcoat **420**.

The reflective polarizer **403** is positioned on the second electrode **434**.

The transmissive axis of reflective polarizer **403** is parallel to the transmissive axis of the first polarizer **120**. The reflective axis of reflective polarizer **403** is in a direction perpendicular to the transmissive axis.

Light that vibrates in a direction parallel to the transmissive axis of the reflective polarizer **403** is transmitted, while light that vibrates in a direction perpendicular to the transmissive axis, that is, a direction parallel to the reflection axis, is reflected.

A reflective polarization film may be used as the reflective polarizer **403**, and a dual brightness enhancement film (DBEF), a wire grid polarizer (WGP), or a TiO_2 multilayer film may be used, as an example, but it is not limited thereto.

The display panel **100** according to an example embodiment, except for the polarization conversion panel **400**, will now be schematically described with reference to FIGS. **3** to **6**.

FIG. **3** is a top plan view of the display panel according to an example embodiment, and for convenience, some constituent elements are illustrated in FIG. **3**.

The display panel according to an example embodiment includes a substrate **110** that is made of a material such as glass and plastic, with a roof layer **360** formed thereon.

The substrate **110** includes a plurality of pixel areas PX.

The plurality of pixel areas PX are disposed in a matrix form including a plurality of pixel rows and a plurality of pixel columns.

Each pixel area PX may include a first subpixel area PXa and a second subpixel area PXb.

The first and second subpixel areas PXa and PXb may be vertically disposed.

A first valley V**1** is positioned between the first and second subpixel areas PXa and PXb along a pixel row direction, and a second valley V**2** is positioned between a plurality of pixel columns.

This configuration is the same as that of the valleys V along the microcavities **405** of polarization conversion panel **400**, and configurations for forming the microcavities **405** to be described later will also be the same.

The roof layer **360** is formed in a pixel row direction.

In this case, the injection hole **307** (FIG. **5**) is formed by removing the roof layer **360** at the first valley V**1** to expose a constituent elements positioned under the roof layer **360** to the outside.

Each roof layer **360** is formed so as to be separated from the substrate **110** between the adjacent second valleys V**2** to form the microcavity **305**.

Further, each roof layer **360** is formed such that it is attached to the substrate **110** at the second valley V**2** to cover both lateral sides of the microcavity **305**.

A structure of the display device according to an example embodiment described above is an example, and may be variously modified.

For example, an arrangement of the pixel area PX, the first valley V**1**, and the second valley V**2** may be modified, a plurality of roof layers **360** may be connected to each other at the first valley V**1**, and a part of each roof layer **360** may be formed to be separated from the substrate **110** at the second valley V**2** such that the adjacent microcavities **305** can be connected to each other.

In addition, the microcavity **305** and the constituent elements related thereto that are described in the display panel **100** may also be applied to the polarization conversion panel **400**.

Next, referring to FIGS. **4** to **6**, one pixel of the display device according to an example embodiment will be described as follows.

FIG. **4** is a top plan view of one pixel of the display panel according to the example embodiment, FIG. **5** is a partial cross-sectional view of the display panel according to the example embodiment taken along the line V-V of FIG. **3**, and FIG. **6** is a partial cross-sectional view of the display panel according to the example embodiment taken along the line VI-VI of FIG. **3**.

Referring to FIGS. **3** to **6**, a plurality of gate conductors including a plurality of gate lines **121**, a plurality of step-down gate lines **123**, and a plurality of storage electrode lines **131** are formed on the substrate **110**.

The gate line **121** and the step-down gate line **123** mainly extend in a horizontal direction to transmit gate signals.

The gate conductor further includes a first gate electrode **124*h*** and a second gate electrode **124I** that protrude upward and downward from the gate line **121**, and a third gate electrode **124*c*** protruding upward from the step-down gate line **123**.

The first gate electrode **124*h*** and the second gate electrode **124I** are connected with each other to form one protruding portion.

In this case, protruding shapes of the first, second, and third gate electrodes **124*h*, 124*l*,** and **124*c*** may be modified.

The storage electrode line **131** mainly extends in a horizontal direction to transmit a predetermined voltage such as a common voltage Vcom.

The storage electrode line **131** includes a storage electrode **129** protruding upward and downward, a pair of vertical portions **134** extending downward to be substantially perpendicular to the gate line **121**, and a horizontal portion **127** connecting ends of the pair of vertical portions **134**.

The horizontal portion **127** includes a capacitor electrode **137** expanded downward.

A gate insulating layer **140** is formed on the gate conductors **121**, **123**, **124***h*, **124***l*, **124***c*, and **131**.

The gate insulating layer **140** may be made of an inorganic insulating material such as a silicon nitride (SiN_x), a silicon oxide (SiO_x), etc.

Further, the gate insulating layer **140** may consist of a single layer or multiple layers.

A first semiconductor **154***h*, a second semiconductor **154***l*, and a third semiconductor **154***c* are formed on the gate insulating layer **140**.

The first semiconductor **154***h* may be positioned on the first gate electrode **124***h*, the second semiconductor **154***l* may be positioned on the second gate electrode **124**I, and the third semiconductor **154***c* may be positioned on the third gate electrode **124***c*.

The first and second semiconductors **154***h* and **154***l* may be connected to each other, and the second and third semiconductors **154***l* and **154***c* may be connected to each other.

Further, the first semiconductor **154***h* may be formed to extend below the data line **171**.

The first to third semiconductors **154***h*, **154***l*, and **154***c* may be made of amorphous silicon, polycrystalline silicon, a metallic oxide, etc.

Ohmic contacts (not shown) may be further formed on the first to third semiconductors **154***h*, **154***l*, and **154***c*, respectively.

The ohmic contacts may be made of a silicide or a material such as n+ hydrogenated amorphous silicon in which n-type impurities are highly doped.

A data conductor including a data line **171**, a first source electrode **173***h*, a second source electrode **173***l*, a third source electrode **173***c*, a first drain electrode **175***h*, a second drain electrode **175***l*, and a third drain electrode **175***c* is formed on the first to third semiconductors **154***h*, **154***l*, and **154***c*.

The data line **171** transmits a data signal and mainly extends in a vertical direction to cross the gate line **121** and the step-down gate line **123**.

Each data line **171** includes the first source electrode **173***h* and the second source electrode **173***l* that extend toward the first gate electrode **124***h* and the second gate electrode **124***l*, and are connected to each other.

The first drain electrode **175***h*, the second drain electrode **175***l*, and the third drain electrode **175***c* include one wide end portions and the other rod-shaped end portions, respectively. The rod-shaped end portions of the first and second drain electrodes **175***h* and **175***l* are partially surrounded by the first and second source electrodes **173***h* and **173***l*.

One wide end portion of the second drain electrode **175***l* further extends to form the third source electrode **173***c* that is bent in a "U" shape.

A wide end portion **177***c* of the third drain electrode **175***c* overlaps the capacitor electrode **137** to form a step-down capacitor Cstd, and the rod-shaped end portion thereof is partially surrounded by the third source electrode **173***c*.

The first gate electrode **124***h*, the first source electrode **173***h*, and the first drain electrode **175***h* form a first thin film transistor Qh together with the first semiconductor **154***h*. The second gate electrode **124**I, the second source electrode **173**I, and the second drain electrode **175**I form a second thin film transistor QI together with the second semiconductor **154**I. The third gate electrode **124***c*, the third source electrode **173***c* and the third drain electrode **175***c* form the third thin film transistor Qc together with the third semiconductor **154***c*.

The first semiconductor **154***h*, the second semiconductor **154**I, and the third semiconductor **154***c* are connected to each other to be linearly formed, and may have substantially the same planar shape as the data conductors **171**, **173***h*, **173**I, **173***c*, **175***h*, **175**I, and **175***c* and the ohmic contacts therebelow, except for channel regions between the source electrodes **173***h*, **173**I, and **173***c* and the drain electrodes **175***h*, **173**I, and **175***c*.

In the first semiconductor **154***h*, an exposed portion that is not covered by the first source electrode **173***h* and the first drain electrode **175***h* is disposed between the first source electrode **173***h* and the first drain electrode **175***h*. In the second semiconductor **154**I, an exposed portion that is not covered by the second source electrode **173**I and the second drain electrode **175**I is disposed between the second source electrode **173**I and the second drain electrode **175**I. In the third semiconductor **154***c*, an exposed portion that is not covered by the third source electrode **173***c* and the third drain electrode **175***c* is disposed between the third source electrode **173***c* and the third drain electrode **175***c*.

A passivation layer **180** is formed on the data conductors **171**, **173***h*, **173**I, **173***c*, **175***h*, **175***l*, and **175***c* and exposed portions of the semiconductors **154***h*, **154***l*, and **154***c* between the respective source electrodes **173***h*, **173***l*, **173***c* and the respective drain electrodes **175***h*, **175***l*, **175***c*.

The passivation layer **180** may be made of an organic insulating material or an inorganic insulating material, and may be formed as a single layer or multiple layers.

A color filter **230** in each pixel area PX is formed on the passivation layer **180**.

Each color filter **230** may display one of the primary colors such as red, green, and blue.

The color filter **230** is not limited to the three primary colors of red, green, and blue, but may display one of cyan, magenta, yellow, and white-based colors.

Unlike what is illustrated above, the color filter **230** may further extend in a column direction along the adjacent data lines **171**.

A light blocking member **220** is formed in a region between the adjacent color filters **230**.

The light blocking member **220** is formed on a boundary of the pixel area PX and the thin film transistor to prevent light leakage.

The color filter **230** is formed in each of the first subpixel area PXa and the second subpixel area PXb, and the light blocking member **220** may be formed between the first subpixel area PXa and the second subpixel area PXb.

The light blocking member **220** extends along the gate line **121** and the step-down gate line **123** such that it expands upward and downward, and includes a horizontal light blocking member **220***a* that covers regions in which the first thin film transistor Qh, the second thin film transistor QI, and the third thin film transistor Qc are positioned, and a vertical light blocking member **220***b* that extends along the data line **171**.

That is, the horizontal light blocking member **220***a* may be formed at a position that corresponds to the position of the first valley V1 (FIG. **5**), and the vertical light blocking member **220***b* may be formed at a position that corresponds to the position of the second valley V2 (FIG. **6**).

The color filter **230** and the light blocking member **220** may overlap each other in some regions.

A first insulating layer **240** may be further formed on the color filter **230** and the light blocking member **220**.

The first insulating layer **240** may be made of an inorganic insulating material such as a silicon nitride (SiN_x), a silicon oxide (SiO_x), and a silicon oxynitride (SiO_xN_y).

The first insulating layer **240** serves to protect the color filter **230** and the light blocking member **220** that are made of an organic material, and may be omitted if necessary.

The first insulating layer **240**, the light blocking member **220**, and the passivation layer **180** are formed with a plurality of first contact holes **185***h* and a plurality of second contact holes **185***l* that respectively expose the wide end portion of the first drain electrode **175***h* and the wide end portion of the second drain electrode **175***l*.

A pixel electrode **191** is formed on the first insulating layer **240**.

The pixel electrode **191** may be made of a transparent metallic material such as indium tin oxide (ITO), indium zinc oxide (IZO), etc.

The pixel electrode **191** is divided while interposing the gate line **121** and the step-down gate line **123** into a first subpixel electrode **191***h* and a second subpixel electrode **191***l* that are disposed at upper and lower parts of the pixel area based on the gate line **121** and the step-down gate line **123**, and are adjacent to each other in a column direction.

That is, the first and second subpixel electrodes **191***h* and **191***l* are separated from each other while interposing the first valley V1 therebetween, the first subpixel electrode **191***h* is positioned in the first subpixel area PXa, and the second subpixel electrode **191***l* is positioned in the second subpixel area PXb.

The first and second subpixel electrodes **191***h* and **191***l* are connected to the first and drain electrodes **175***h* and **175***l* through the first and second contact holes **185***h* and **185***l*, respectively.

Accordingly, when the first and second thin film transistors Qh and Ql are turned on, the first and second thin film transistors Qh and Ql are applied with data voltages from the first and second drain electrodes **175***h* and **175***l*.

Each of the first and second subpixel electrodes **191***h* and **191***l* roughly has a quadrangular shape, and the first and second subpixel electrodes **191***h* and **191***l* include a cross-shaped stem portion consisting of horizontal stem portions **193***h* and **193***l* and vertical stem portions **192***h* and **192***l* that cross the horizontal stem portions **193***h* and **193***l*, respectively.

In addition, the first and second subpixel electrodes **191***h* and **191***l* include a plurality of micro branch portions **194***h* and **194***l*, and protruding portions **197***h* and **197***l* protruding downward or upward from edge sides of the first and second subpixel electrodes **191***h* and **191***l*, respectively.

The subpixel electrodes **191***h* and **191***l* are divided into four subregions by the horizontal stem portions **193***h* and **193***l* and the vertical stem portions **192***h* and **192***l*.

The micro branch portions **194***h* and **194***l* obliquely extend from the horizontal stem portions **193***h* and **193***l* and the vertical stem portions **192***h* and **192***l*, and may form an angle of about 45 to 135 degrees with respect to the gate line **121** or the horizontal stem portions **193***h* and **193***l* in their extending direction.

Further, directions in which the micro branch portions **194***h* and **194***l* of the two adjacent subregions extend may be perpendicular to each other.

In the present example embodiment, the first subpixel electrode **191***h* further includes an outer stem portion surrounding its periphery, and the second subpixel electrode **191***l* includes horizontal portions positioned at upper and lower ends, and left and right vertical portions **198** positioned at left and right sides of the first subpixel electrode **191***h*.

The left and right vertical portions **198** may prevent capacitive coupling between the data line **171** and the first subpixel electrode **191***h*.

The arrangement of the pixel area, the structure of the thin film transistor, and the shape of the pixel electrode that are described above are examples, and the present invention is not limited thereto, but may be variously modified.

Referring to FIGS. **5** and **6**, a common electrode **270** is formed on the pixel electrode **191** such that it is spaced apart from the pixel electrode **191** by a predetermined distance.

A microcavity (display microcavity) **305** is formed between the pixel electrode **191** and the common electrode **270**.

That is, the microcavity **305** is surrounded by the pixel electrode **191** and the common electrode **270**.

A width and an area of the microcavity **305** may be variously modified according to a size and resolution of the display device.

The common electrode **270** may be made of a transparent metallic material such as indium tin oxide (ITO), indium zinc oxide (IZO), etc.

The common electrode **270** may be applied with a predetermined voltage, and an electric field may be generated between the pixel electrode **191** and the common electrode **270**.

A first alignment layer **11** is formed on the pixel electrode **191**.

The first alignment layer **11** may also be formed directly on the first insulating layer **240** that is not covered by the pixel electrode **191**.

A second alignment layer **21** is formed under the common electrode **270** to face the first alignment layer **11**.

The first and second alignment layers **11** and **21** may be formed in a vertical alignment layer, and may be made of an alignment material such as polyamic acid, polysiloxane, polyimide, etc.

The first and second alignment layers **11** and **21** may be connected to each other at edges of the pixel area PX.

A liquid crystal layer formed by liquid crystal molecules **31** is formed in the microcavity **305** that is positioned between the pixel electrode **191** and the common electrode **270**.

The liquid crystal molecules **31** have negative dielectric anisotropy, and may be erected in a direction perpendicular to the substrate **110** when no electric field is applied.

That is, vertical alignment may be realized.

The first and second subpixel electrodes **191***h* and **191***l* to which the data voltages are applied generate the electric field together with the common electrode **270** to determine directions of the liquid crystal molecules **31** that are positioned in the microcavity **305** between the two electrodes **191** and **270**.

As such, luminance of light passing through the liquid crystal layer varies according to the determined directions of the liquid crystal molecules **31**.

A second insulating layer **350** may be further formed on the common electrode **270**.

The second insulating layer **350** may be made of an inorganic insulating material such as a silicon nitride (SiN_x), a silicon oxide (SiO_x), a silicon oxynitride (SiO_xN_y), etc., and may be omitted if necessary.

A roof layer **360** is formed on the second insulating layer **350**.

The roof layer **360** may be made of an organic material.

The microcavity **305** is formed below the roof layer **360**, and the roof layer **360** may be hardened by a hardening process to maintain the shape of the microcavity **305**.

That is, the roof layer **360** is formed to be spaced apart from the pixel electrode **191** while interposing the microcavity **305** therebetween.

The roof layer **360** is formed in each pixel area PX and in the second valley V**2** along a pixel row, and is not formed in the first valley V**1**.

That is, the roof layer **360** is not formed between the first and second subpixel areas PXa and PXb.

The microcavity **305** is formed below each roof layer **360** in the first and second subpixel areas PXa and PXb.

In the second valley V**2**, the microcavity **305** is not formed below the roof layer **360**, but is formed to be attached to the substrate **110**.

Accordingly, the roof layer **360** positioned at the second valley V**2** may be formed to have a greater thickness than the roof layer **360** positioned in each of the first and second subpixel areas PXa and PXb.

A top surface and both lateral sides of the microcavity **305** is formed such that they are covered with the roof layer **360**.

An injection hole **307** that partially exposes the microcavity **305** is formed in the common electrode **270**, the second insulating layer **350**, and the roof layer **360**.

The injection holes **307** may be formed so as to face each other at edges of the first subpixel area PXa and the second subpixel area PXb.

That is, the injection holes **307** may be formed such that they correspond to a lower side of the first subpixel area PXa and an upper side of the second subpixel area PXb so as to expose lateral sides of the microcavity **305**.

Because the microcavity **305** is exposed by the injection hole **307**, an aligning agent or a liquid crystal material may be injected into the microcavity **305** through the injection hole **307**.

An overcoat **390** may be formed on a third insulating layer **370**.

The overcoat **390** is formed to cover the injection hole **307** through which the microcavity **305** is partially exposed to the exterior of the microcavity **305**.

That is, the overcoat **390** may seal the microcavity **305** such that the liquid crystal molecules **31** formed in the microcavity **305** are not discharged outside of the microcavity **305**.

Because the overcoat **390** contacts the liquid crystal molecules **31**, the overcoat **390** may be made of a material that is not reactive with the liquid crystal molecules **31**.

For example, the overcoat **390** may be made of parylene and the like.

The overcoat **390** may consist of multiple layers, such as a double layer and a triple layer structure.

The double layer structure consists of two layers that are made of different materials.

The triple layer structure consists of three layers, and materials of adjacent layers are different from each other.

For example, the overcoat **390** may include a layer that is made of an organic insulating material and a layer that is made of an inorganic insulating material.

As shown in FIG. **1**, polarizers (first polarizer **120** and a second polarizer **130**) may be further formed on upper and lower sides of the display device.

The polarizers may consist of a first polarizer **120** and a second polarizer **130**.

The first polarizer **120** may be attached to a lower side of the substrate **110**, while the second polarizer **130** may be attached to the overcoat **390**.

The display device including the display panel **101** (FIG. **1**) and the polarization conversion panel **400** (FIG. **1**) that are described above may reduce the number of substrates used, thereby reducing the thickness and weight of the display device.

Further, improved touch sensing is provided to the display device having an additional touch panel.

Next, a manufacturing method of a display device according to an example embodiment will be described as follows.

Referring to FIGS. **4**, **5** and **6**, first, a gate line **121** and a step-down gate line **123** that extend in one direction are formed on a substrate **110** that is made of glass or plastic, and a first gate electrode **124*h***, a second gate electrode **124*l***, and a third gate electrode **124*c*** that protrude from the gate line **121** are formed.

Further, a storage electrode line **131** may be integrally formed such that it is spaced apart from the gate line **121**, the step-down gate line **123**, and the first to third gate electrodes **124*h***, **124*l***, and **124*c***.

Next, a gate insulating layer **140** is formed on the entire surface of the substrate **110** including the gate line **121**, the step-down gate line **123**, and first to third gate electrodes **124*h***, **124*l***, and **124*c***, and the storage electrode line **131**, by using an inorganic insulating material such as a silicon nitride (SiN_x) and a silicon oxide (SiO_x).

The gate insulating layer **140** may be formed with a single layer or multiple layers.

Next, a first semiconductor **154*h***, a second semiconductor **154*l***, and a third semiconductor **154*c*** are formed by depositing a semiconductor material such as amorphous silicon, polycrystalline silicon, and a metallic oxide on the gate insulating layer **140** and then patterning the deposited semiconductor material.

The first semiconductor **154*h*** may be positioned on the first gate electrode **124*h***, the second semiconductor **154*l*** may be positioned on the second gate electrode **124I**, and the third semiconductor **154*c*** may be positioned on the third gate electrode **124*c***.

Next, a data line **171** that extends in the other direction is formed by depositing the metallic material and then patterning the deposited metallic material.

The metallic material may consist of a single layer or multiple layers.

Further, a first source electrode **173*h*** protruding above the first gate electrode **124*h*** from the data line **171** and a first drain electrode **175*h*** spaced apart from the first source electrode **173*h*** are integrally formed.

Further, a second source electrode **173*l*** connected to the first source electrode **173*h*** and a second drain electrode **175*l*** spaced apart from the second source electrode **173*l*** are integrally formed.

Further, a third source electrode **173*c*** extending from the second drain electrode **175*l*** and a third drain electrode **175*c*** spaced apart from the third source electrode **173*c*** are integrally formed.

After being consecutively deposited, the semiconductor material and the metallic material may be simultaneously patterned to form the first to third semiconductors **154*h***, **154*l***, and **154*c***, the data line **171**, the first to third source electrodes **173*h***, **173*l***, and **173*c***, and the first to third drain electrodes **175*h***, **175*l***, and **175*c***.

In this case, the first semiconductor **154*h*** may be formed to extend below the data line **171**.

The first, second, and third gate electrodes **124***h*, **124***l*, and **124***c*, the first, second, and third source electrodes **173***h*, **173***l*, and **173***c*, and the first, second, and third drain electrodes **175***h*, **175***l*, and **175***c* form first, second, and third thin film transistors (TFTs) Qh, Ql, and Qc together with the first, second, and third semiconductors **154***h*, **154***l*, and **154***c*, respectively.

Subsequently, a passivation layer **180** is formed on the data line **171**, the first to third source electrodes **173***h*, **173***l*, and **173***c*, the first to third drain electrodes **175***h*, **175***l*, and **175***c*, and exposed portions of the semiconductors **154***h*, **154***l*, and **154***c* between the source electrodes **173***h*, **173***l*, and **173***c* and the drain electrodes **175***h*, **175***l*, and **175***c*.

The passivation layer **180** may be made of an organic insulating material or an inorganic insulating material, and may be formed with a single layer or multiple layers.

Next, a color filter **230** is formed in each pixel area PX on the passivation layer **180**.

The color filter **230** is formed in each of the first subpixel area PXa and the second subpixel area PXb, and may not be formed at the first valley V**1**.

Further, the color filters **230** having the same color may be formed along a column direction of the plurality of pixel areas PX.

In case of forming the color filters **230** of three colors, a color filter **230** of a first color may be formed first and then a color filter **230** of a second color may be formed by shifting a mask.

Next, after forming the color filter **230** of the second color, a color filter **230** of a third color may be formed by shifting the mask.

Next, a light blocking member **220** is formed on a boundary of each pixel area PX on the passivation layer **180** and the thin film transistor.

The light blocking member **220** may be formed at the first valley V**1** that is positioned between the first and second subpixel areas PXa and PXb.

In the above description, the light blocking member **220** is formed after forming the color filters **230**, but the present disclosure is not limited thereto, and the light blocking member **220** may be formed first and then the color filters **230** may be formed.

Next, a first insulating layer **240** made of an inorganic insulating material such as a silicon nitride (SiN_x), a silicon oxide (SiO_x), a silicon oxynitride (SiO_xN_y), etc. is formed on the color filter **230** and the light blocking member **220**.

Next, a first contact hole **185***h* is formed by etching the passivation layer **180**, the light blocking member **220**, and the first insulating layer **240** such that it partially exposes the first drain electrode **175***h*, and a second contact hole **185***l* is formed such that it partially exposes the second drain electrode **175***l*.

Next, a first subpixel electrode **191***h* and a second subpixel electrode **191***l* are respectively formed in the first and second subpixel areas PXa and PXb by depositing and then patterning a transparent metallic material such as indium tin oxide (ITO) and indium zinc oxide (IZO) on the first insulating layer **240**.

The first and second subpixel electrodes **191***h* and **191***l* are separated from each other while interposing the first valley V**1** therebetween.

The first subpixel electrode **191***h* is formed to be connected to the first drain electrode **175***h* through the first contact hole **185***h*, and the second subpixel electrode **191***l* is formed to be connected to the second drain electrode **175***l* through the second contact hole **185***l*.

Horizontal stem portions **193***h* and **193***l* and vertical stem portions **192***h* and **192***l* crossing the horizontal stem portions **193***h* and **193***l* are respectively formed in the first and second subpixel electrodes **191***h* and **191***l*.

Further, a plurality of micro branch portions **194***h* and **194***l*, which obliquely extend from the horizontal stem portions **193***h* and **193***l* and the vertical stem portions **192***h* and **192***l*, are formed.

A photosensitive organic material is coated on the pixel electrode, and then a photolithography process is performed to form a sacrificial layer (not shown).

The sacrificial layers (not shown) are formed to be connected to each other along the plurality of pixel columns.

That is, the sacrificial layer (not shown) is formed to cover each pixel area PX and the first valley V**1** that is positioned between the first and second subpixel areas

PXa and PXb.

Subsequently, a common electrode **270** is formed by depositing a transparent metallic material such as indium tin oxide (ITO) and indium zinc oxide (IZO) on the sacrificial layer (not shown).

Next, a second insulating layer **350** may be formed on the common electrode **270** by using an inorganic insulating material such as a silicon nitride (SiN_x), a silicon oxide (SiO_x), a silicon oxynitride (SiO_xN_y), etc.

Next, an organic material is coated and then patterned on the second insulating layer **350** to form a roof layer **360**.

In this case, the patterning may be performed to remove the organic material positioned at the first valley V**1**.

Accordingly, the roof layers **360** may be formed to be connected to each other along a plurality of pixel rows.

The sacrificial layer (not shown) is completely removed by supplying a developer and a stripper solution on the substrate **110** where the sacrificial layer (not shown) is exposed, or by an ashing process.

When the sacrificial layer (not shown) is removed, the microcavity **305** is created at a position where the sacrificial layer (not shown) is positioned.

The pixel electrode **191** and the common electrode **270** are spaced apart from each other while interposing the microcavity **305** therebetween, and the pixel electrode **191** and the roof layer **360** are spaced apart from each other while interposing the microcavity **305** therebetween.

The common electrode **270** and the roof layer **360** are formed to cover a top surface and both lateral sides of the microcavity **305**.

The microcavity **305** is exposed outside through a portion where the roof layer **360**, the second insulation layer **350**, and the common electrode **270** are removed, which is the injection hole **307**.

The injection hole **307** may be formed along the first valley V**1**.

For example, injection holes **307** may be formed to face each other at edges of the first and second subpixel areas PXa and PXb.

That is, the injection hole **307** may be formed such that it corresponds to a lower side of the first subpixel area PXa and an upper side of the second subpixel area PXb so as to expose lateral sides of the microcavity **305**.

Alternatively, the injection hole **307** may be formed along the second valley V**2**.

Next, the roof layer **360** is hardened by applying heat to the substrate **110**.

This is to maintain a shape of the microcavity **305** by the roof layer **360**.

Next, when an aligning agent containing an alignment material is dripped on the substrate **110** by a spin coating method or an inkjet method, the aligning agent is injected into the microcavity **305** through the injection hole **307**.

When the aligning agent is injected into the microcavity **305** and then a hardening process is performed, a solution component is evaporated and the alignment material remains at an inner wall of the microcavity **305**.

Accordingly, the first alignment layer **11** may be formed on the pixel electrode **191**, and the second alignment layer **21** may be formed below the common electrode **270**.

The first and second alignment layers **11** and **21** are formed to face each other while interposing the microcavity **305** therebetween, and are connected to each other at the edges of the pixel area PX.

In this case, the first and second alignment layers **11** and **21** may be aligned in a direction that is perpendicular to the substrate **110** except at the lateral sides of the microcavity **305**.

In addition, by performing a process of irradiating ultraviolet rays to the first and second alignment layers **11** and **21**, the alignment layers **11** and **21** may be aligned in a direction parallel to the substrate **110**.

Next, when the liquid crystal material formed by liquid crystal molecules **31** is dripped on the substrate **110** by an inkjet method or a dispensing method, the liquid crystal material is injected into the microcavity **305** through the injection hole **307**.

In this case, the liquid crystal material may be dropped in the injection holes **307** that are formed along the odd-numbered first valleys V**1**, and may not be dripped in the injection holes **307** that are formed along the even-numbered first valleys V**1**.

Alternatively, the liquid crystal material may be dripped in the injection holes **307** that are formed along the even-numbered first valleys V**1**, and may not be dripped in the injection holes **307** formed along the odd-numbered first valleys V**1**.

When the liquid crystal material is dripped in the injection holes **307** that are formed along the odd-numbered first valleys V**1**, the liquid crystal material passes through the injection hole **307** by capillary force such that it is placed inside the microcavity **305**.

In this case, because air inside the microcavity **305** is discharged through the injection holes **307** that that are formed along the even-numbered first valleys V**1**, the liquid crystal material enters into the microcavity **305**.

Further, the liquid crystal material may be dripped in all of the injection holes **307**.

That is, the liquid crystal material may be dripped in all of the injection holes **307** that are formed along the odd-numbered first valleys V**1** and the even-numbered first valleys V**1**.

An overcoat **390** is formed by depositing a material that is not reactive with the liquid crystal molecules **31** on the third insulating layer **370**.

The overcoat **390** is formed such that it covers the injection hole **307** where the microcavity **305** is exposed outside and seals the microcavity **305**.

Next, though not illustrated in FIGS. **5** and **6**, additional polarizers may be attached to the upper and lower sides of the display device.

The polarizers may consist of a first polarizer **120** and a second polarizer **130** (FIG. **1**).

The second polarizer **130** may be attached to a bottom surface of the substrate **110**, while first polarizer **120** may be attached on the overcoat **390**.

A manufacturing method of a polarization conversion panel **400** will now be described with reference to FIGS. **7** to **9**.

First, as shown in FIG. **7**, a first electrode **404** is formed by depositing a transparent metallic material such as indium tin oxide (ITO) and indium zinc oxide (IZO) on one surface of an insulation substrate **401**.

Next, as shown in FIG. **8**, a photosensitive organic material is coated on the first electrode **404**, and then a photolithography process is performed to form a sacrificial layer **500**.

As shown in FIG. **3**, the sacrificial layer **500** is formed in a matrix form consisting of a plurality of islands.

Next, a passivation layer **410** is formed on the sacrificial layer **500** by using an inorganic insulating material such as a silicon nitride (SiN_x), a silicon oxide (SiO_x), a silicon oxynitride (SiO_xN_y), etc.

Next, by partially etching the passivation layer **410**, the sacrificial layer is exposed, and the sacrificial layer **500** can be completely removed by supplying a developer and a stripper solution on the substrate **401** where the sacrificial layer is exposed, or by an ashing process.

When the sacrificial layer is removed, the microcavity **405** is created at a position where the sacrificial layer is positioned.

The microcavity **405** is exposed to the exterior of the polarization conversion panel through a portion where the passivation layer **410** is removed, which is the injection hole **407**. Next, the substrate **401** may be heated to harden the passivation layer **410**.

This is to maintain the shape of the microcavity **405** by the passivation layer **410**.

Next, when an aligning agent containing an alignment material is dripped on the substrate **401** by a spin coating method or an inkjet method, the aligning agent is injected into the microcavity **405** through the injection hole **407**.

When the aligning agent is injected into the microcavity **405** and then a hardening process is performed, a solution component is evaporated and the alignment material remains at an inner wall of the microcavity **405**.

Thus, an alignment layer (not shown) may be formed on the first electrode **404**, and another alignment layer (not shown) may be formed below the passivation layer **410**.

The alignment layers may be formed to face each other while interposing the microcavity **405** therebetween.

In this case, the alignment layers may be aligned in a direction perpendicular to the substrate **401** except at the lateral sides of the microcavity **405**.

In addition, by performing a process of irradiating ultraviolet rays to the alignment layers, the alignment layers may be aligned in a direction parallel to the substrate **401**.

In the present disclosure, the example embodiment in which the alignment layers are formed by a UV irradiation process has been described, but it is not limited thereto, and the alignment layers may be formed by a photo-alignment process.

Next, when the liquid crystal material consisting of the liquid crystal molecules **31** is dripped on the substrate **401** by an inkjet method or a dispensing method, the liquid crystal material is injected into the microcavity **405** through the injection holes **407**.

When the liquid crystal material is dripped in the injection holes **407**, the liquid crystal material passes through the injection hole **407** by capillary force such that it is placed inside the microcavity **405**.

In this case, because air inside the microcavity **405** is discharged through the injection holes **407** that are formed along the even-numbered valleys V, the liquid crystal material enters into the microcavity **405**.

Further, the liquid crystal material may be dripped in all of the injection holes **407**.

That is, the liquid crystal material may be dripped in all of the injection holes **407** that are formed along the odd-numbered valleys V and the even-numbered valleys V.

Next, as shown in FIG. **9**, an overcoat **420** is formed by depositing a material that is not reactive with the liquid crystal molecules **31** on the passivation layer **410**.

The overcoat **420** is formed such that it covers the injection hole **407** where the microcavity **405** is exposed outside and seals the microcavity **405**.

Next, a second electrode **434** (FIG. **2**A) is formed by depositing a transparent metallic material such as indium tin oxide (ITO) and indium zinc oxide (IZO) on the overcoat **420**.

Next, the polarization conversion panel **400** illustrated in FIG. **2**A can be manufactured by positioning the reflective polarizer **403** on the second electrode **434** and the absorptive polarizer **402** on the other side of the insulation substrate **401** formed before.

The display device including the polarization conversion panel manufactured as such may reduce the width and weight of the device because it requires fewer substrates, and the polarization conversion panel and the display panel may be bonded to each other to improve weakness that each panel has.

A driving mechanism of a polarization conversion panel according to an example embodiment will now be described with reference to FIGS. **10** and **11**.

FIG. **10** shows a driving mechanism of the polarization conversion panel according to an example embodiment to which no voltage is applied, and FIG. **11** shows a driving mechanism of the polarization conversion panel according to an example embodiment to which a voltage is applied.

According to the polarization conversion panel illustrated in FIGS. **10** and **11**, liquid crystals are in a vertically aligned ("VA") mode, transmissive axes of a first polarizer **120** and a reflective polarizer **403** are parallel to each other, and the transmissive axis of the reflective polarizer **403** is perpendicular to a transmissive axis of the absorptive polarizer **402**.

In addition, the liquid crystals of the VA mode have been described, but they are not limited thereto, and the liquid crystals of an OCB (optically compensated ben) mode or a PLS (plane to line switching) mode may also be included.

FIG. **10** shows how the light is transmitted when the voltage is applied, while FIG. **11** shows how the light is transmitted when no voltage is applied.

Next, referring to FIG. **10**, a case in which no voltage is applied to the polarization conversion panel will be described.

Incident light from the outside has polarization axes in all directions, but only light with its polarization axis in one direction passes through the absorptive polarizer **402** while the remainder of the light is absorbed by the absorptive polarizer **402**.

As an example, the light in the horizontal direction is transmitted.

The light desired to have a predetermined polarization axis passes through the polarization conversion panel in the VA mode that is applied with the voltage while maintaining its polarization axis.

As an example embodiment, the polarization axes of the reflective polarizer **403** and the absorptive polarizer **402** are perpendicular to each other, while the transmissive and reflection axes of the reflective polarizer **403** are perpendicular to each other.

The transmissive and reflective axes of the reflective polarizer **403** are respectively in the vertical and horizontal directions such that the light having its polarization axis in the horizontal direction is completely reflected because its polarization axis is in parallel with the reflective axis of the reflective polarizer **403**.

Such a transmittance property is equally applied to the light that is emitted outside after being reflected from the reflective polarizer **403**.

The light reflected from the reflective polarizer **403** maintains its current polarization axis while passing through the polarization conversion panel **400**, and thus is transmitted therethrough as its polarization axis is parallel to the transmissive axis of the absorptive polarizer **402**.

As described above, because the light incident upon the display device is reflected from the reflective polarizer **403** when no voltage is applied to the polarization conversion panel and is then incident to a user's eyes, the display device provides a mirror function.

Next, referring to FIG. **11**, a case in which voltage is applied to the polarization conversion panel will be described.

First, among incident light from the outside, only the light having the same polarization axis as the transmissive axis of the absorptive polarizer **402** passes through the absorptive polarizer **402**, and the remainder of the light is absorbed by the absorptive polarizer **402**.

Referring to FIG. **11**, as an example, only the light having the transmissive axis in the horizontal direction is transmitted.

The polarization axis of the light that is polarized by the absorptive polarizer **402** in one direction is rotated by 90 degrees while passing through the liquid crystals of the VA mode to which the voltage is applied.

The light with its polarization axis rotated by 90 degrees has a vertical polarization axis.

The light having the vertical polarization axis has the polarization axis parallel to the transmissive axis of the reflective polarizer **403** such that it is completely transmitted therethrough.

Such light transmission is equally applied to the light emitting out of the display panel **100**.

The light polarized by the display panel **100** and the first polarizer **120** has a polarization axis parallel to the transmissive axis of the first polarizer **120**.

The transmissive axes of the first polarizer **120** and the reflective polarizer **403** are parallel to each other such that the light transmitted through the first polarizer **120** also passes through the reflective polarizer **403**.

Next, the light transmitted through the liquid crystals of the VA mode to which the voltage is applied has its polarization axis rotated by 90 degrees.

Thus, the incident light having the vertical polarization axis is emitted outside such that it has the horizontal polarization axis.

Because the transmissive axes of the reflective polarizer **403** and the absorptive polarizer **402** are perpendicular to each other, the light having the horizontal polarization axis passes through the absorptive polarizer **402** because its polarization axis is parallel to the transmissive axis of the absorptive polarizer **402**.

Thus, the light emitting out of the display panel **100** displays the image without having additional polarization conversion when the voltage is applied to the polarization conversion panel **400**.

A display device according to an example embodiment will now be described with reference to FIGS. **12** and **13**.

FIG. **12** is an image showing a mode of the display device in which a display image is shown, and FIG. **13** is an image of the display device operated in a mirror mode with no voltage applied to the polarization conversion panel.

FIG. **12** is a case in which the voltage is applied to the conversion panel according to the example embodiment and the display panel displays an outputted image.

In the present disclosure, as an example, a printed material is placed under the polarization conversion panel such that it is seen by a user's eyes.

When the display panel is positioned at a position where the printed material is placed, the user's eyes may recognize the image that the display panel outputs.

Referring to FIG. **13**, which is a case in which no voltage is applied according to an example embodiment, and as a result, the polarization conversion panel provides a reflective mode in which the mirror function is implemented.

That is, according to the aforementioned principle, the polarization conversion panel **400** including the liquid crystals of the VA mode liquid crystals may provide a mode in which it displays an image when the voltage is applied and operating as a mirror when no voltage is applied

Accordingly, the display device according to example embodiments has an advantage of having reduced thickness and weight as well as implementing the mirror and display mode.

While example embodiments have been described in connection with what is presently considered to be practical example embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the disclosure, including the appended claims.

<Description of Symbols>

100: display panel	400: polarization conversion panel
401: insulation substrate	402: absorptive polarizer
404: first electrode	304, 405: microcavity
307, 407: injection hole	180, 410: passivation layer
390, 420: overcoat	434: second electrode
403: reflective polarizer	

What is claimed is:

1. A display device comprising:

a display panel; and

a polarization conversion panel facing the display panel, wherein

the polarization conversion panel includes:

an insulation substrate;

an absorptive polarizer positioned on the insulation substrate;

a first electrode positioned on the absorptive polarizer;

a passivation layer formed on the first electrode while being spaced apart therefrom and a microcavity interposed between the passivation layer and the first electrode, the passivation layer including an injection hole;

an overcoat formed on the passivation layer to cover the injection hole and seal the microcavity;

a second electrode positioned on the overcoat;

a reflective polarizer positioned on the second electrode; and

a liquid crystal layer positioned in the microcavity.

2. The display device of claim **1**, wherein

the display panel contacts the reflective polarizer.

3. The display device of claim **1**, wherein

the first and second electrodes are made of a transparent conductive oxide (TCO).

4. The display device of claim **1**, wherein

a first polarizer positioned between the display panel and the reflective polarizer is further included, and

transmissive axes of the first polarizer and the reflective polarizer coincide with each other.

5. The display device of claim **4**, wherein

the transmissive axis of the reflective polarizer is perpendicular to a transmissive axis of the absorptive polarizer.

6. The display device of claim **4**, wherein

a reflective axis of the reflective polarizer is parallel to the transmissive axis of the absorptive polarizer.

7. The display device of claim **4**, wherein

the transmissive and reflective axes of the reflective polarizer are perpendicular to each other.

8. The display device of claim **1**, wherein

the display panel includes:

a substrate including a plurality of pixel areas that are arranged in a matrix form including a plurality of pixel rows and pixel columns;

a thin film transistor formed on the substrate;

a pixel electrode formed in the pixel area while being connected to the thin film transistor;

a roof layer formed on the pixel electrode while being spaced apart therefrom and interposing a display microcavity therebetween;

a liquid crystal layer filling the display microcavity; and

an overcoat formed on the roof layer to cover the first injection hole and seal the display microcavity.

* * * * *